"Some Experiments on Helium." By MORRIS W. TRAVERS, B.Sc. Communicated by Professor W. RAMSAY, F.R.S. Received December 30, 1896,—Read February 4, 1897.

In July of last year Professors Runge and Paschen ('Phil Mag.,' 1895, [ii], vol. 40, pp. 297—302) announced their discovery that the spectrum of the gas from clèveite indicated the presence of two elements. They also stated that by means of a single diffusion through an asbestos plug, they had been able to effect a partial separation of the lighter constituent, which was characterised by the green glow which it gave under the influence of the electric discharge in a vacuum-tube, and which was represented in the spectrum by the series containing the green line, $\lambda = 5015{\cdot}6$. Subsequently, at the meeting of the British Association at Ipswich, Professor Runge exhibited a tube containing the so-called green constituent; the colour of the glow differed strongly from that of an ordinary helium tube, but the gas contained in it was evidently at very low pressure, as phosphorescence was just commencing. Professor Runge has since acknowledged that the green effect in the helium tube may be produced by a change of pressure alone ('Astrophysical Journal,' January, 1896).

During an exhibition of the spectrum of helium at the soirée of the Royal Society on May 9, 1895, it was noticed that one of the Plücker tubes which had been running for nearly three hours, had become strongly phosphorescent. The tube was fitted with platinum electrodes, and the helium had apparently been absorbed by the platinum sparked on to the walls of the tube. We observed the same phenomena to take place on several subsequent occasions, but only in the case of tubes with platinum electrodes.*

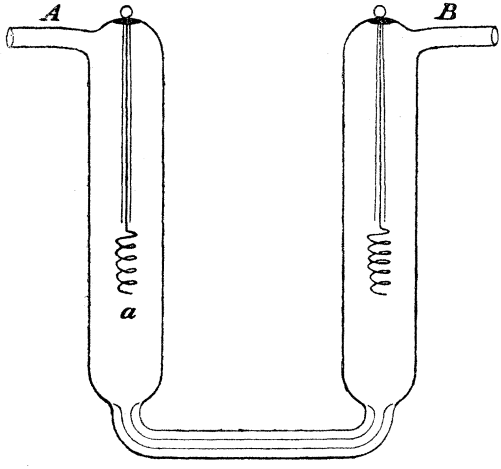
Now, if helium is not a single gas, it must consist of a mixture of two or more monatomic gases, capable of mechanical separation, and it is possible that one of its constituents might be absorbed by the platinum faster than the other. At the end of September, 1895, I commenced some experimental work on this subject, with the view of separating the two or more possible constituents from one another. The results were negative.

I employed in these experiments a piece of apparatus figured below (fig. 1).

A large Plücker tube, bent into a U-shape, has two side-tubes, A and B. The electrodes are of platinum, and project far into the tube; the straight parts, which are of thick wire, and about 30 mm.

* So far as I know, this phenomenon was first recorded by Professor Norman Lockyer ('Roy. Soc. Proc.,' 1895, vol. 58, p. 193).

Fig. 1.



long, are protected by a sheath of thin glass tube, the spirals at their ends being of thin platinum wire. The side-tube A is connected, by means of a tube containing pentoxide of phosphorus, with an apparatus for the introduction of gases into vacuum-tubes ('Trans. Chem. Soc.,' 1895, p. 686). The tube B is connected with a tap on the Töpler's pump. The apparatus was first thoroughly exhausted and heated by a Bunsen's flame, and then, after closing the tap on B, helium was introduced at about 3 mm. pressure. The electrodes were connected with the secondary terminal of a coil, and the current was turned on, making *a* the cathode. A deposit of platinum quickly appeared on the walls of the tube round *a*, and the following changes took place in the colour of the glow:—

1. Yellow, with slight tinge of red.
2. Bright yellow.
3. Yellowish-green.
4. Green; green line very strong.
5. Green, with phosphorescence.
6. Phosphorescent vacuum; spark passed between electrodes outside the tube.

The tube was then connected with the pump by opening the tap on B, but, as might have been expected, no trace of gas could be removed. The tap was again closed, and the tube was warmed carefully with a Bunsen's burner. The gas was slowly given off from the platinum, and on passing the discharge, colour-changes were observed to take place in the glow, from green to yellow.

From this experiment, it was obvious that the whole of the helium would be absorbed by the platinum splashed off, but it yet remained

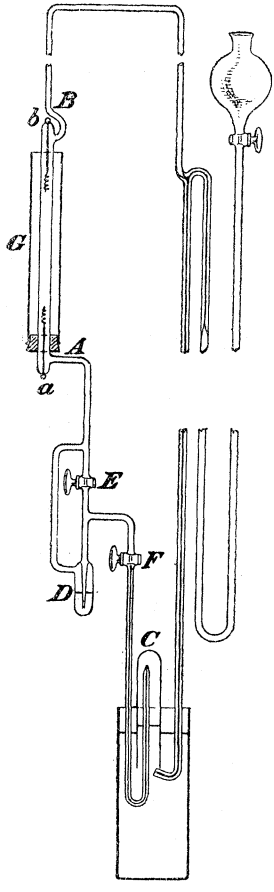
to be proved that the change in colour in the glow was not due to the absorption of the yellow constituent more quickly than the green one.

The vacuum-tube used in the last experiment was again filled with helium to about 3 mm. pressure, and the discharge was passed till the glow had become green, and the green line had reached its maximum intensity. Now, if any separation had taken place, the gas which had been absorbed by the platinum should contain a large proportion of the yellow constituent of helium, and should give a yellow glow in a vacuum-tube, even at low pressure. The remaining gas in the tube was, therefore, removed by pumping, and after closing the tap on B, the gas was driven off from the platinum, by warming with a Bunsen's flame. The current was then turned on, and a glow appeared of the green colour invariably shown by helium at low pressure. The change of colour in the tube during absorption of the helium is, therefore, to be entirely attributed to the lowering of the pressure. In describing these experiments I have used the term absorption in its general sense, as it is impossible to say at present whether we are dealing with a case of simple occlusion or not. The platinum, when it is deposited, is black and non-metallic in appearance, but, on heating, it assumes the colour and general character of ordinary platinum, and sometimes breaks away from the tube in thin scales. The change is probably the same as that which takes place when platinum-black is heated.

In a few of my experiments, I used helium containing traces of hydrogen, nitrogen, and carbon compounds. In these cases I found that not only was the helium absorbed, but also the other gases, to a greater or less extent. Hydrogen is readily absorbed, and next in order come carbon compounds and nitrogen. Argon is taken up only in very small quantity; in fact, this process serves as a method of separation of helium from argon, even when the helium is present to the amount of only 2 per cent.

To carry out this separation, the gas is made to circulate at about 3 mm. pressure, through a vacuum-tube of the type used in the last experiment. To effect this, the Töpler's pump is replaced by a Sprengel's pump, arranged as shown in fig 2, to deliver the gas removed from the vacuum-tube back into the tube C. To regulate the supply of gas entering the apparatus, the tap F was carefully turned, till the gas bubbled slowly through the mercury contained in the small tube D. The tap E served as a by-pass during the preliminary pumping-out of the apparatus, and was closed during the experiment. By carefully regulating the quantity of gas which entered the apparatus, and the rate of flow of mercury in the Sprengel's pump, it was possible to maintain a constant pressure in the apparatus for a long time.

FIG. 2.



To facilitate the absorption of the gases during the experiment, the vacuum-tube was kept cool by a water-jacket, G, closed at the bottom by a cork fitting tightly round the tube. When it was necessary to heat the vacuum-tube, the jacket could be loosened from the cork, and slipped up the side-tube B, which was bent round, and extended vertically for about 10 inches in a straight line with the vacuum-tube.

The gas was made to circulate for about six hours, and at the end of that time the tap F was closed, the tap E was opened, and the apparatus thoroughly exhausted. The jacket G was then raised, and the gas expelled from the platinum by heat was pumped off. From mixtures containing very little helium, a small quantity of that gas was separated, mixed with a trace of argon.

Kayser and Friedländer ('Chem. Zeitung,' vol. 9, p. 1529) have stated that in a vacuum-tube fitted with platinum electrodes, and containing atmospheric argon, the argon became absorbed by the deposited platinum, and the tube then showed certain of the helium lines. I have never been able to absorb argon to more than the very slightest extent, and though I have often had argon-tubes, which have become black, owing to the deposition of platinum, through which a powerful discharge has passed for many hours, I have never noticed any marked absorption.

A specimen of argon, the lightest fraction obtained from Professor Ramsay's diffusion experiments, was treated in the manner just described. After several hours' circulation it was found that the gas absorbed by the platinum consisted only of argon, and no trace of helium could be detected. This process has also been applied to the analysis of the gases from certain mineral springs; the results of these experiments form the subject of another paper.

"On the Gases enclosed in Crystalline Rocks and Minerals."

By W. A. TILDEN, D.Sc., F.R.S. Received December 19, 1896,—Read February 4, 1897.

It has long been known* that many crystallised minerals contain gas enclosed in cavities in which drops of liquid are also frequently visible. The liquid often consists of water and aqueous solutions, occasionally of hydrocarbons, and not unfrequently of carbon dioxide, the latter being recognisable by the peculiarities of its behaviour under the application of heat. The liquid supposed to be carbon dioxide has been found in some cases to pass from the liquid to the gaseous state, and therefore to disappear, and to return from gas to liquid at temperatures lower by two or three degrees than the critical point of carbon dioxide. This seems to indicate the presence of some incondensable gas, and as H. Davy found nitrogen in the fluid cavities of quartz, it seemed probable that the alteration of the critical point was due to that gas.

My attention was drawn to this subject by the observation that Peterhead granite, when heated in a vacuum, gives off several times its volume of gas, consisting, to the extent of three-fourths of its volume, of hydrogen ('Roy. Soc. Proc.,' vol. 59, p. 218).

* The chief literature of this subject is contained in the following papers:—Brewster, 'R. S. Edin. Trans.,' 1824, vol. 10, p. 1; 'Edin. J. Science,' vol. 6, p. 115; Simmler, 'Pogg. Ann.,' vol. 105, p. 460; Sorby and Butler, 'Roy. Soc. Proc.,' vol. 17, p. 291; Vogelsang and Geissler, 'Pogg. Ann.,' vol. 137, pp. 56 and 257; Hartley, 'C. S. Trans.,' 1876, vol. 1, p. 137, and vol. 2, p. 237, also 1877, vol. 1, p. 241.